UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Revised Occupational and Residential Exposure Assessment And Recommendations For The Reregistration Eligibility Decision (RED) for Piperonyl Butoxide

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This document provides an assessment of occupational and residential exposure and risk for piperonyl butoxide. This document updates the July 15, 2004 Occupational and Residential Exposure Assessment. This document has been revised to address public comments submitted on the March 11, 2005 HED risk assessment.

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1.0 Executive Summary

1.1 Background and Purpose

This occupational and residential exposure and risk assessment is being conducted as part of EPA's human health risk assessment for the Piperonyl Butoxide Reregistration Eligibility Decision (RED) Document. This document addresses exposures and risks associated with both the occupational and residential exposure to piperonyl butoxide based on label prescribed uses.

1.2 Use Patterns and Formulations

Piperonyl butoxide is a synergist used in a wide variety of pesticide formulations. Synergists are chemicals that lack pesticidal effects of their own but enhance the pesticidal properties of other chemicals. Piperonyl butoxide is an ingredient in pesticide formulations used in both residential and commercial applications. Commercial uses include pesticides for agricultural food and nonfood crops, food and non-food processing commercial establishments (indoor and outdoor premises), agricultural structures, equipment, and premises both with and without animals present, and direct application to veterinary and farm animals. Residential uses include pest control in homes and outdoor domestic structures, on gardens, lawns, and ornamentals, and direct application to household pets. As a synergist, piperonyl butoxide's mode of action is to impede an insect's ability to breakdown pesticides like pyrethrum and the synthetic pyrethroids by inhibiting the mixed function oxidase system of the insect. Piperonyl butoxide is available primarily in liquid formulations but is also available in powder, dust and granular formulations. It is applied by commercial and residential applicators by a wide spectrum of application equipment methods. Comprehensive information on use patterns and formulations is provided in the Piperonyl Butoxide Master Label which was submitted to the Agency by the Piperonyl Butoxide Task Force II. Task force members include Prentiss, Inc., McLaughlin Gormley King Co., S.C. Johnson & Son, Inc., Takasago International Corp., Endura S.p.A., and Valent Biosciences Corp.

1.3 Hazard Identification

The Report of the Hazard Identification Assessment Review Committee (HIARC) for piperonyl butoxide, (TXR NO., 0052600, S. Ramasamy, 6/8/04) identified the following toxicological endpoints of concern for piperonyl butoxide. No dose or endpoints were selected for dermal exposure. HIARC concluded that no quantitative dermal assessment is required because no systemic effects were observed at the limit dose in the 21-day dermal absorption study in rabbits. In the 21-day rabbit study, dermal dose levels of 1000 mg/kg/day produced no treatment related effect on mortality rate, food consumption, body weight gain, hematology, clinical chemistry, absolute/relative organ weights, and histopathology. However, piperonyl butoxide was observed to be a mild irritant i.e., macro and micropathology of the tested sites exhibited dermal lesions associated with irritation.

For acute inhalation exposure (e.g., < 2 hours) the toxicology endpoint was selected from

a rat developmental study in which the oral No Observed Adverse Effect Level (NOAEL) was 630 mg/kg/day based on maternal decrease in body weight gain during gestation at the Lowest Observed Adverse Effect Level (LOAEL) of 1065 mg/kg/day. In the absence of appropriate acute inhalation toxicity studies, the default value of 100% for inhalation absorption was used for route-to-route extrapolations. The target margin of exposure (MOE) for acute inhalation exposures to piperonyl butoxide is 100 based on the conventional uncertainty factor of 100X (10X for intraspecies extrapolation and 10X for interspecies variation).

For short-, intermediate- and long-term inhalation exposures, the toxicology endpoint was selected from a subchronic inhalation toxicity study in rats in which the LOAEL was 3.91 mg/kg/day based on laryngeal hyperplasia and metaplasia. A respiratory NOAEL was not established because lesions in the larynx were present in all treated groups. The selected endpoint is considered appropriate for assessing all durations of inhalation exposure based on route and duration of the study. The target MOE for short and intermediate term inhalation exposures to piperonyl butoxide is 300. The short- and intermediate-term target MOE includes the conventional uncertainty factor of 100X, and an additional 3X uncertainty factor for the use of a LOAEL. The target MOE for long term inhalation exposures is 1000. The long-term target MOE is increased to 1000 due to lesions in the respiratory tract that might progress into long term adverse effects (e.g., cancer). The long-term target MOE includes the conventional uncertainty factor of 100X, an additional 3X uncertainty factor for the use of a LOAEL, and an additional 3X to account for potential long term adverse effects due to long term exposure.

For short- and intermediate-term incidental oral exposure, an oral NOAEL of 89 mg/kg/day was selected from a two generation reproduction study in rats based on decrease in body weight gain of F_1 and F_2 pups at postnatal day 21 at the LOAEL of 469 mg/kg/day. Since the pup weights are affected significantly during lactation phase at postnatal day 21, and there is a trend for decrease in pup weight at postnatal day 4, the endpoints selected are considered appropriate for assessing risks to infants and children from this exposure scenario. The target MOE for incidental oral exposure is 100 based on the conventional uncertainty factor of 100X.

The toxicity database is considered adequate for evaluation of risks to infants and children. Studies indicate that there is a low degree of concern for the fetal susceptibility effects and no evidence of residual uncertainties for pre- and post-natal toxicity from exposure to piperonyl butoxide. No developmental toxic effects were noted in guideline studies in rats and rabbits. Neurotoxic effects are not evident from the clinical signs reported in developmental, reproductive and chronic studies. Therefore, the FQPA safety factor is reduced from 10x to 1x.

1.4 Occupational and Residential Exposure and Risk

Piperonyl butoxide is a widely used pesticide chemical. It has an extraordinary number of use patterns that are impossible to capture completely in this assessment. However, representative scenarios believed to represent the vast majority of piperonyl butoxide uses are assessed. Based on toxicological criteria and potential for exposure, HED has conducted

inhalation and incidental oral exposure assessments for a variety of occupational and residential scenarios. Dermal exposures were not assessed because HIARC concluded that no quantitative dermal assessment is required because no systemic effects were observed at the limit dose in dermal toxicity studies in animals. Occupational and residential exposure via inhalation routes can occur during mixing, loading, application, and post-application activities. Incidental oral exposures to toddlers can occur during residential post-application activities. Acute, short, intermediate- and long-term MOEs were calculated for this assessment as required based on label specified use/exposure patterns.

Thirty one exposure scenarios were identified as representative of occupational exposure from piperonyl butoxide uses. These include 14 scenarios involving agricultural applications; 12 scenarios for pesticide control operators; 4 scenarios for mosquito abatement applications and one scenario for veterinary/pet grooming applications. Occupational post-application scenarios were not assessed because there is no endpoint for the dermal exposure, the only relevant route of concern for worker post-application exposure. Twelve exposure scenarios were assessed for residential exposure, three for residential handler activities and nine for residential post-application activities. An assessment of residential exposure from use of indoor metered release misters was not conducted due to data limitations. HED recommends that label restrictions provided in the master label be required for indoor automatic mister uses. An assessment of exposures from use of outdoor automatic misters is provided in a separate memorandum, "Occupational and Residential Exposure Assessment for the Use of Piperonyl Butoxide in Residential Outdoor Automatic Mister Systems" (M. Crowley, D315334, 8/30/05).

Occupational and residential exposure and risk estimates were conducted using maximum application rates and HED standard default assumptions for area of application and/or amount of product applied for most exposure scenarios. Available compound and scenario specific data were also used as appropriate for some scenarios. A target MOE of 100 is considered adequate for acute inhalation exposure. A target MOE of 300 is considered adequate for short- and intermediate-term occupational and residential exposure via inhalation. A target MOE of 1000 is considered adequate for long-term worker inhalation exposures. A target MOE of 100 is considered adequate for exposure via incidental ingestion by toddlers.

Exposure estimates indicate MOEs of concern (< the target MOE) at the maximum use rate for the following ten occupational scenarios.

- Mixing and loading wettable powders for aerial and/or chemigation application to field crops The target MOE for this scenario is 300. The estimated MOE for the maximum application rate of 0.5 lb ai per acre is 40.
- Mixing and loading wettable powders for groundboom application to field crops. The target MOE for this scenario is 300. The estimated MOE for the maximum application rate of 0.5 lb ai per acre is 160.
- Mixing, loading and applying liquids with high pressure hand wand for greenhouse application. The target MOE for this scenario is 300. The estimated MOE for the maximum application rate of 1.5 lb ai per acre is 160.

- Mixing, loading and applying wettable powders with low pressure hand wand or backpack sprayer for greenhouse application. The target MOE for this scenario is 300. The estimated MOE for the maximum application rate of 1.5 lb ai per acre is 85.
- Mixing, loading and applying liquids indoors for crack and crevice application with low pressure handwand. The target MOE for this scenario is 1000. The estimated MOE for the maximum application rate of 2.2 lb ai per 1000 ft^2 is 380.
- Mixing, loading and applying wettable powders indoors for surface spray application with low pressure handwand. The target MOE for this scenario is 1000. The estimated MOE for the maximum application rate of 0.56 lb ai per 1000 ft^2 is 40.
- Mixing, loading and applying wettable powders indoors for crack and crevice application with low pressure handwand. The target MOE for this scenario is 1000. The estimated MOE for the maximum application rate of 2.2 lb ai per 1000 ft^2 is 10.
- Application of aerosol spray indoors. The target MOE for this scenario is 1000. The estimated MOE for the likely maximum ai concentration of 2.5% is 615.
- Mixing and loading liquids for aerial applications for mosquito abatement The target MOE for this scenario is 1000. The estimated MOE for the maximum application rate of 0.08 lb ai per acre is 390.
- Mixing, loading, applying liquids for mosquito applications with truck mounted ULV ground spray - open cab. The target MOE for this scenario is 1000. The estimated MOE for the maximum application rate of 0.08 lb ai per acre is 260.

All other occupational exposure scenarios assessed based on uses specified in the master label indicate exposures below the level of concern i.e., estimated MOEs are above the applicable target MOE.

The results of the residential exposure assessment indicate that all residential exposure scenarios assessed based on master label specified uses result in MOEs greater than the applicable target MOEs and are therefore below the level of concern.

2.0 Hazard Identification

2.1 Acute Toxicology Categories

Table 1 presents the acute toxicity categories as outlined in the Hazard Identification Document.

Table 1. Acute Toxicity of Piperonyl Butoxide

Guideline No.	Study Type	MRID #(s)	Results	Toxicity Category
81-1	Acute Oral	41969001	LD_{50} = 4570 mg/kg (m) LD_{50} = 7220 mg/kg (f)	Category IV
81-2	Acute Dermal	41969002	LD_{50} = >2000mg/kg	Category IV
81-3	Acute Inhalation	41990001	LC_{50} = >5.9 mg/L	Category IV
81-4	Primary Eye Irritation	41969004	Minimally irritating	Category III

81-5	Primary Skin Irritation	41969003	Minimally irritating	Category III
81-6	Dermal Sensitization	41969005	Negative	Category IV

2.2 Toxicological Endpoints

The report of the HIARC for piperonyl butoxide identified toxicological endpoints of concern for piperonyl butoxide. All calculations completed in this document are based on the most current toxicity information available for piperonyl butoxide as reported in the HIARC document. The endpoints that were used to complete this assessment are summarized below in Table 2.

Table 2: Selected Endpoints for Assessing Occupational and Residential Risks for Piperonyl Butoxide

Exposure Scenario	Dose Used in Risk Assessment, UF	Special FQPA SF* and Level of Concern for Risk Assessment	Study and Toxicological Effects
Acute Dietary General Population	NOAEL= **630** mg/kg/day UF = **100** **Acute RfD** = **6.3** mg/kg/day	FQPA SF = **1X** **aPAD** = acute RfD / FQPA SF = **6.3** mg/kg/day	Developmental toxicity study, rats (Tanaka et al., 1995a) LOAEL = **1065 mg/kg/day** based on decrease in maternal body weight gain
Acute Dietary Females 13-49 years	N/A	N/A	Acute Dietary Endpoint for General Population is considered protective for this population. No separate endpoint is selected.
Chronic Dietary (All populations)	NOAEL= **15.5** mg/kg/day UF = **100** **Chronic RfD** = **0.16** mg/kg/day	FQPA SF = **1X** **cPAD** = chronic RfD / FQPA SF = **0.16** mg/kg/day	Chronic oral toxicity study, dogs LOAEL = **52.8** mg/kg/day based on decrease in body weight gain, and increases in alkaline phosphatase activity, liver weight and hepatocellular hypertrophy
Short-Term Incidental Oral (1-30 days)	NOAEL= **89** mg/kg/day	**Residential** MOE = **100** **Occupational** MOE= **100**	Two generation reproduction study, rats LOAEL = **469** mg/kg/day based on the decrease in body weight gain of F_1 and F_2 pups at postnatal day 21
Intermediate-Term Incidental Oral (1- 6 months)	NOAEL= **89** mg/kg/day	**Residential** MOE = **100** **Occupational** MOE = **100**	Two generation reproduction study, rats LOAEL = **469** mg/kg/day based on the decrease in body weight gain of F_1 and F_2 pups at postnatal day 21
Short-Term Dermal (1 to 30 days); Intermediate-Term Dermal (1 to 6 months); Long-Term Dermal (>6 months)	N/A Dermal Absorption = 2%	N/A	No systemic, developmental and neurotoxicity concerns at the Limit Dose. Oral NOAELs with the dermal absorption factor result in dermal equivalent doses approximately equal to or higher than the Limit Dose. Therefore, no quantification is required. Piperonyl butoxide is classified as mild irritant. Contact should be avoided.

Table 2: Selected Endpoints for Assessing Occupational and Residential Risks for Piperonyl Butoxide			
Exposure Scenario	**Dose Used in Risk Assessment, UF**	**Special FQPA SF* and Level of Concern for Risk Assessment**	**Study and Toxicological Effects**
Acute Inhalation (≤ 2 hrs) (inhalation absorption rate = **100** %)	NOAEL= **630** mg/kg/day	**Residential** MOE = **100**	Developmental toxicity study, rats (Tanaka et al., 1995a) LOAEL = **1065 mg/kg/day** based on decrease in maternal body weight gain
Short-Term Inhalation (1 to 30 days)	Respiratory LOAEL= **3.91** mg/kg/day (0.015 mg/L)	**Residential** MOE = **300** **Occupational** MOE = **300**	Subchronic inhalation toxicity study, rats Respiratory LOAEL = **3.91** mg/kg/day (0.015 mg/L) based on laryngeal hyperplasia and metaplasia
Intermediate-Term Inhalation (1 to 6 months)	Respiratory LOAEL= **3.91** mg/kg/day (0.015 mg/L)	**Residential** MOE = **300** **Occupational** MOE = **300**	Subchronic inhalation toxicity study, rats Respiratory LOAEL = **3.91** mg/kg/day (0.015 mg/L) based on laryngeal hyperplasia and metaplasia
Long-Term Inhalation (>6 months)	Respiratory LOAEL= **3.91** mg/kg/day (0.015 mg/L)	**Residential** MOE = **1000** **Occupational** MOE = **1000**	Subchronic inhalation toxicity study, rats Respiratory LOAEL = **3.91** mg/kg/day (0.015 mg/L) based on laryngeal hyperplasia and metaplasia
Cancer	NA	NA	Classified as "Group C carcinogen" with RfD approach for quantification

3.0 Summary of Use Patterns and Formulations

3.1 Target Pests

Piperonyl butoxide containing insecticides are used to control vast numbers and types of pests including various types of ants, worms, beetles, mites, flies, gnats, spiders, weevils, caterpillars, grubs, moths, ticks, lice, wasps, aphids, midges and others. General applications for which piperonyl butoxide is currently registered include the following:

- Food/Feed Crops (domestic and commercial): root and tuber vegetables, leafy vegetables, legume vegetables, fruiting vegetables, curcurbit vegetables, citrus fruits, berries, nuts, stored grain and seed, greenhouse fruit and vegetable plants

- Farm Animals: beef and dairy cattle, hogs/pigs/swine, goat, sheep, rabbits, game, and poultry, donkeys, horses, ponies, mules

- Outdoor Non-food Plants (domestic and commercial): ornamentals, lawns, groundcover,

greenhouse non-food plants

- Agricultural Indoor and Outdoor Structures, Premises, and Equipment
- Commercial/Industrial Indoor and Outdoor Structures, Premises, and Equipment (includes eating establishments and food processing plants and equipment)
- Indoor Domestic Dwellings
- Outdoor Domestic Buildings and Premises
- Pets: cats, dogs, and all other domestic animals

3.2 Formulations

Based on EPA's pesticide registration database and information provided by the Piperonyl Butoxide Task Force, piperonyl butoxide is available as a technical manufacturing product, formulation intermediate, and the following currently active forms: liquid, emulsifiable concentrate, soluble concentrate, ready-to-use solution, dust, wettable powder, microencapsulate, impregnated materials, pressurized gas, and granular. Formulation products range from 0.02% to 75% a.i.

3.3 Registered Use Sites and Application Rates

Maximum application rates for various application categories are provided in Table 3. Maximum rates are based primarily on information provided in the Piperonyl Butoxide Master Label which was submitted to the Agency by the Piperonyl Butoxide Task Force II and supplemental review of active labels.

Table 3. Master Label Data Report - Piperonyl Butoxide Occupational and Residential Uses*

Site Category	Max AR	# App
Professional Agricultural & Commercial Uses		
Pre-harvest Agricultural Food Crops (Field & Greenhouse)	0.5 lb ai/A	10/season
Non-food Crops - Greenhouses	1.5 lb ai/A	1/day
Post-Harvest Food Crops	0.1 lb ai/ 1000 ft^2	1/7days
Post-Harvest Application to Stored Grain and Seed	0.5 lb ai/ 1000 ft^2	1/month
Application to Farm Equipment and Premise	1 lb ai/A	1/day
Commercial & Domestic Structures Premises & Equipment - Surface Application	0.56 lb ai/ 1000 ft^2	NA
Commercial & Domestic Structures Premises and Equipment - Space Application (e.g., total release fogger)	0.03 lb ai/ 1000 ft^3	NA
Commercial & Domestic Structures - Crack and Crevice	2.2 lb/1000 ft^2	NA
Commercial and Domestic Outdoor Sites	3.5 lb ai/A	NA
Ornamentals, Lawns, Groundcovers	1 lb ai/A	NA

Table 3. Master Label Data Report - Piperonyl Butoxide Occupational and Residential Uses*		
Site Category	**Max AR**	**# App**
Mosquito Abatement - Adulticide	0.08 lb ai/A	NA
Direct Application to Animals (Livestock, Farm Animals, Pets)	10%	NA
Residential Uses		
Garden Crops	0.6 lb ai/A	10/season
Domestic Dwellings - Surface Application	0.56 lb ai/ 1000 ft^2	NA
Domestic Dwellings - Space Application (e.g., total release fogger)	0.03 lb ai/1000 ft^3	NA
Domestic Dwellings -Crack and Crevice	2.2 lb ai/ 1000 ft^2	NA
Ornamental Woody Shrubs & Vines, Lawns, Turf	1 lb ai/A	NA
Out Door Premises	1 lb ai/A	NA
Direct Application to Pets	10 % ai	NA

* Based on the Master Label, it is assumed that products for all applications are supported/available in multiple forms i.e., liquids, dust, wettable powders

3.4 Application Methods and Equipment

Piperonyl butoxide is applied with the following types of equipment; aerosol can, non-aerosol pump spray, hand held sprayer, backpack sprayer, mist blower, metered aerosol unit, total release aerosol, fixed wing aircraft, helicopter, truck-mounted ultra low volume (ULV) equipment, cold aerosol generators, conventional mechanical compressed air equipment and conventional hydraulic sprayers (e.g., high and/or low pressure handwand), thermal fogging equipment, conventional dusting equipment (e.g., power duster, shaker can), gas operated liquid dispenser systems, automated sequential sprayers, and irrigation systems.

4.0 Incident Report

Based on data from Poison Control Centers, there appears to be a greater risk of moderate or major symptoms among those exposed to products containing pyrethrins and piperonyl butoxide than those exposed to pyrethrins alone. A detailed review of symptoms found that respiratory symptoms (bronchospasm, cough/choke, and dyspnea) and selected dermal symptoms (dermal irritation/pain, itching, and rash) were more likely if the exposure included piperonyl butoxide. These symptoms are likely the reason for increased risk of moderate effects which typically would require medical attention. Other literature suggests that pyrethrin-based products may pose a hazard to asthmatics. The findings from analysis of symptoms from Poison Control Centers suggests that piperonyl butoxide adds to that risk.

Based on these findings, it is recommended that labeling advise handlers using products containing piperonyl butoxide as follows: Avoid contact with skin or eyes. Susceptible individuals may experience irritant or allergic-type reactions. Persons with respiratory illness may experience difficulty breathing and should avoid use in enclosed spaces and consult their physician prior to use. (Review of Pyrethrins Incident Reports - Second Revision, J. Blondell, D320300, 8/16/04)

5.0 Occupational Exposure and Risk

Based on the Master Label, 31 occupational exposure scenarios have been assessed for this RED. Only inhalation exposures have been assessed for each of the occupational scenarios. Dermal exposures were not assessed because no dose or endpoints were selected for dermal exposure. Short, intermediate, and long-term exposures are expected/assessed for occupational exposure scenarios based on use patterns. Agricultural handler exposures are assessed as short- and intermediate-term. Pesticide control operator exposures are assessed as short-, intermediate- and long-term. Mosquito abatement exposures are assessed as short- and intermediate-term for aerial and backpack spray applications and short-, intermediate-, and long-term for truck mounted ULV spray applications.

5.1 Occupational Exposure Scenarios

Only occupational handler scenarios were assessed for the piperonyl butoxide RED. The term "handler" applies to individuals who mix, load, and apply the pesticide product. Occupational post-application scenarios were not assessed because there is no endpoint for the dermal exposure, the only relevant route of concern for post-application worker exposure. Based primarily on information provided in the Piperonyl Butoxide Master Label regarding current registrant supported uses, HED assessed the following scenarios for agricultural, professional pest control operator, and mosquito control applications for the piperonyl butoxide RED. Application of dust with shaker can, bulb duster and power duster, a relevant and potentially significant exposure scenario was not assessed due to lack of dust-specific or adequate surrogate data on inhalation exposure associated with this activity.

5.1.1 Agricultural Handler Scenarios

1) mixing and loading liquids for aerial and/or chemigation application to field crops
2) mixing and loading liquids for groundboom application to field crops
3) mixing and loading liquids for airblast application to field crops
4) mixing and loading wettable powders for aerial and/or chemigation application to field crops
5) mixing and loading wettable powders for groundboom application to field crops
6) mixing and loading wettable powders for airblast application to field crops
7) applying liquids aerially to field crops
8) applying liquids with ground boom sprayer to field crops
9) applying liquids with airblast sprayer to field crops
10) mixing, loading and applying liquids with high pressure hand wand for greenhouse application
11) mixing, loading and applying liquids with backpack sprayer or low pressure handwand for greenhouse application
12) mixing loading and applying wettable powder with backpack sprayer or low pressure hand wand for greenhouse application
13) mixing, loading and applying liquids with backpack sprayer or low pressure hand

wand for agricultural premise and equipment application
14) flagging for aerial spray application

5.1.2 Pesticide Control Operator Handler Scenarios

1) mixing, loading and applying liquids indoors for surface spray application with low pressure handwand;
2) mixing, loading and applying liquids indoors for crack and crevice application with low pressure handwand;
3) mixing, loading and applying wettable powders indoors for surface spray application with low pressure handwand;
4) mixing, loading and applying wettable powders indoors for crack and crevice application with low pressure handwand;
5) mixing, loading and applying liquids with backpack sprayer or low pressure hand wand for general outdoor sites;
6) mixing, loading and applying liquids for hand gun sprayer application to lawns;
7) mixing, loading and applying liquids for groundboom application to golf courses
8) mixing, loading and applying liquids for back pack sprayer or low pressure handwand application to stored grain
9) mixing, loading and applying liquids for high pressure handwand application to stored grain
10) mixing, loading and applying liquids for low pressure handwand application to warehouse stored produce
11) applying liquids to golf courses with groundboom sprayer
12) aerosol spray application indoors

5.1.3 Mosquito Abatement Scenarios

1) mixing, loading liquids for aerial application
2) mixing, loading liquids for ULV truck mounted spray application
3) mixing, loading, applying liquids with truck mounted ULV ground spray (airblast sprayer unit exposure used as surrogate)
4) mixing, loading, applying liquids with back pack sprayer

5.1.4 Direct Application to Pets and Farm Animals (by veterinarians and groomers)

- spray application

5.2 Occupational Exposure Data and Assumptions

5.2.1 Exposure Data

5.2.1.1 Application Parameters

Application rates for all of the exposure scenarios assessed are based on information provided in the Piperonyl Butoxide Master Label. The Master Label was submitted to the Agency by the Piperonyl Butoxide Task Force II, whose members include Prentiss, Inc., McLaughlin Gormley King Co., S.C. Johnson & Son, Inc., Takasago International Corp., Endura S.p.A., and Valent Biosciences Corp. The Master Label, dated February 12, 2003, provides application parameters including type of application, maximum application rate or concentration, and use restrictions pertinent to human exposure and environmental exposure. The information contained in the Master Label was compiled by the Task Force II from hundreds of product labels that contain piperonyl butoxide. The Piperonyl Butoxide Master Label lists all of the uses that the Piperonyl Butoxide Task Force II members are supporting. Therefore, it is important all labels be revised to reflect the supported uses and maximum allowable application rates provided in the Master Label.

5.2.1.2 Occupational Handler Exposure Data

HED Occupational Exposure SOPs

It is the policy of the HED to use data from the Pesticide Handlers Exposure Database (PHED) or Outdoor Residential Exposure Task Force (ORETF) data to assess handler exposures for regulatory actions when chemical-specific monitoring data or other handler-specific data are not available. PHED was designed by a task force of representatives from the US. EPA, Health Canada, the California Department of Pesticide Regulation, and members of the American Crop Protection Association. PHED is a software system consisting of two parts; 1) a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions, and 2) a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates). The ORETF completed four studies which were designed to provide representative, or "generic" surrogate exposure data for residential risk assessment. The studies were designed by the Task Force, which included input from representatives of the crop protection field, regulatory agencies, and commercial applicators. The studies monitored professionals applying granular formulation by push spreader and various formulations by pressurized hose-end "handgun" or spray gun; and volunteers representing non-professional consumers applying granular formulation by push spreader and liquid formulations by garden hose-end sprays. Overall, the four ORETF studies were well-conducted and the data for all scenarios is considered

of better quality and quantity than what is currently contained in PHED. Default application assumptions regarding areas treated or amounts applied for agriculture and mosquito abatement handler exposure scenarios are documented in the HED Science Advisory Committee on Exposure's SOP 9, "Standard Values for Daily Acres Treated in Agriculture" (7/5/2000).

National Pest Management Association Survey

Information on how pest control operators use pesticide products was obtained from a survey conducted by the National Pest Management Association (NPMA). NPMA sponsored a "Pest Control Operators (PCO) Product Use and Usage Information Survey". Using a retrospective telephone survey method, the enumerator (Dr. Richard Patterson of the University of Florida) contacted 148 PCO firms and was able to complete 67 surveys. The survey was national in scope and included 12-23 responses from each of four regions. The survey collected information on where PCOs apply their products, product brands that are used for wood destroying insects and general pest control, and the amount of time PCOs spend on application, travel, equipment set up, mixing/loading products, administrative and other activities.

OPP's Biological and Economic Analysis Division (BEAD) conducted a review of the NPMA survey. BEAD drew the following conclusions regarding the robustness and validity of the survey data. Given that there are approximately 19,000 PCO firms in the U.S., it is highly unlikely that a sample size of 67 represents a statistically valid sample. The use of a retrospective survey methodology may have introduced errors in the data. Pesticide survey firms like Doane use a prospective survey instrument sent to growers in advance thus allowing them to keep detailed accounts of their pesticide usage in real time throughout the year. Despite its small size and retrospective methodology, however, the information collected is far more robust than BEAD typically gets when asking questions of this nature. BEAD typically contacts 1-5 PCO's and asks chemical specific questions which may bias the responses if PCO's value the chemical under review. BEAD believes that the NPMA Survey should be a useful tool for conducting ORE assessments on upcoming RED chemicals. (D. Brassard, D305276, 7/04)

5.2.2 Exposure Assumptions

The following assumptions were used in estimating risks to occupational handlers from exposure to piperonyl butoxide:

- Average body weight of an adult handler is 70 kg
- Exposure duration is short-term and intermediate term for agricultural handlers and short-, intermediate- and long-term for PCOs and mosquito control applicators
- Baseline inhalation exposure (no respiratory protection)
- Maximum application rates as provided by Piperonyl Butoxide Task Force II were used for all types and methods of application; rates used for exposure assessment are provided in Table 3 above
- Maximum daily volumes handled and/or area treated used for the scenarios assessed are as follows

- aerial applications
  · 350 acres per day for typical acreage field crops; 1200 for high acreage field crops (e.g., corn, rice, wheat)
  · 7500 acres per day for mosquito control adulticide applications
- groundboom applications
  · 80 acres treated per day for field crops
  · 40 acres treated per day for golf course turf
- airblast applications - 40 acres treated per day for agricultural applications;
- ULV truck mounted sprayer - 3000 acres treated per day for mosquito control (airblast used as surrogate)
- pet groomer/veterinary applications
  · 8 pet animals are treated per day
  · one half of a 16 oz spray container used to treat each animal
- high pressure handwand application - 10 acres treated or 1000 gallons of spray solution used per day
- backpack sprayer or a low pressure handwand sprayer applications
  · 2 acres treated or 40 gallons spray solution used per day for agricultural premise/mosquito control/general outdoor site applications
  · 5 grain storage bins treated per day with cross-sectional area of 1000 square feet per bin
  · 5 food produce storage warehouses treated per day, area treated per warehouse is 10,000 square feet
- pest control operator applications
  · a maximum of 7 commercial buildings or residential homes treated per day for general pest control management activities
  · average area treated per building is 1600 square feet for surface spray and crack and crevice treatment and 12800 cubic feet for space spray application (EPA Exposure Factors Handbook)

Non-Standard Exposure Assumptions

- Assumptions used for veterinary and grain storage treatments are not included in the Occupational Exposure SOPs but represent values that have been used by the Agency in previous assessments (e.g., carbaryl, cyfluthrin).

- Assumptions used for daily area treated for produce storage warehouses are based on best professional judgement.

- Assumptions used for general pest control applicators are based data from the NPMA survey. Based on BEAD's review of the NPMA survey, PCOs conducting general pest control activities would treat an average of between 6 and 7 buildings per day, assuming an 8-hour work day. According to the EPA Exposure Factors Handbook, a central tendency estimate of the average residential house is 369 m^3 (12800 ft^3). Given a typical ceiling height of 8 feet, the typical house has about 1,600 ft^2 of surface area. Given that

NPMA survey data indicate that PCOs spend approximately the same amount of time applying general pest control formulations to residential and commercial buildings (68 minutes for residential buildings, 70 minutes for day care buildings, and 79 minutes for commercial/institutional buildings), it is assumed that approximately the same area is treated for residential and commercial structures.

- Airblast application unit exposure data was used to assess exposure resulting from truck mounted ULV application of mosquito adulticide. In the absence of more equipment specific data, airblast unit exposure data is thought to provide reasonable surrogate exposure information based on the similarity of the two application methods and has been used for this purpose in previous HED occupational exposure assessments (e.g., carbaryl).

5.3 Occupational Exposure and Risk Estimates

A target MOE of 300 for the inhalation route is considered adequate for short- and intermediate-term occupational exposure and risk. A target MOE of 1000 is considered adequate for long-term worker exposure via the inhalation route. Agricultural handler exposures are assessed as short- and intermediate- term. Pesticide control operator exposures are assessed as short-, intermediate- and long-term. Mosquito abatement worker exposures are assessed as short- and intermediate-term for aerial and backpack spray applications and short-, intermediate-, and long-term for truck mounted ULV spray applications. Exposure and risk estimates for each scenario are summarized below and a more detailed summary of exposure and risk calculations, critical assumptions, and results is provided in Tables 4-7 on pages 27-30.

The results of the worker exposure assessment indicate that the following agricultural application exposure scenarios result in MOEs less than the target MOE of 300 for inhalation for short- and intermediate-term exposure.

- Mixing and loading wettable powders for aerial and/or chemigation application to field crops. The MOE at the maximum application rate of 0.5 lb ai/acre for typical acreage field crops is s 40; the MOE for high acreage field crops is 11. MOEs greater than the target MOE of 300 result at an application rate of 0.06 lb ai/acre for the typical acreage field crop scenario and 0.018 lb ai/acre for the high acreage scenario.

- Mixing and loading wettable powders for groundboom application to field crops. The MOE at the maximum application rate of 0.5 lb ai/acre is 160 . MOEs greater than the target MOE of 300 MOEs result at an application rate of 0.25 lb ai/acre for this scenario.

- Mixing, loading and applying liquids for high pressure handwand application to greenhouse crops. The MOE at the maximum application rate of 1.5 lb ai/acre is 160. MOEs greater than the target MOE of 300 result at an application rate of 0.07 lb ai/acre for this scenario.

- Mixing, loading and applying wettable powders for low pressure handwand application to greenhouse crops. The MOE at the maximum application rate of 1.5 lb ai/acre is 85. MOEs

greater than the target MOE of 300 result at an application rate of 0.4 lb ai/acre for this scenario.

The results of the worker exposure assessment indicate that the following pest control operator application exposure scenarios result in MOEs less than the target MOE of 1000 for long-term exposure.

- Mixing, loading and applying liquids for low pressure handwand application for crack and crevice treatment. The MOE at the maximum application rate of 2.2 lb ai/1000 ft^2 and 7 buildings treated per day is 380. MOEs greater than the target MOE of 1000 result at the maximum application rate of 2.2 lb ai/1000 ft^2 if the number of buildings treated per day is reduced to one, or if the application rate is reduced to 0.3 ai/1000 ft^2 for 7 buildings treated per day.

- Mixing, loading and applying wettable powders for low pressure handwand application for indoor surface spray treatment. The MOE at the maximum application rate of 0.56 lb ai/1000 ft^2 and 7 buildings treated per day is 40. MOEs greater than the target MOE of 1000 result if the application rate is reduced to of 0.16 lb ai/1000 ft^2 and only 1 building is treated per day.

- Mixing, loading and applying wettable powders for low pressure handwand application for crack and crevice treatment. The MOE at the maximum application rate of 2.2 lb ai/1000 ft^2 and 7 buildings treated per day is 10. MOEs greater than the target MOE of 1000 result if the application rate is reduced to of 0.16 lb ai/1000 ft^2 and only 1 building is treated per day.

- Applying aerosols for indoor space spray application. The MOE at the likely maximum application rate of 0.025 lb ai per 16 oz. can with two cans applied per building and 7 buildings treated per day is 615. MOEs greater than the target MOE of 1000 result if the application rate is reduced to 0.012 lb ai per 16 oz can.

The results of the worker exposure assessment indicate that the following mosquito abatement application exposure scenario results in an MOE less than the target MOE of 1000 for long-term exposure.

- Mixing and loading liquids for aerial spray application. The MOE at the maximum application rate of 0.08 lb ai/acre is 390 if an open cab is assumed. MOEs greater than the target MOE of 1000 result if the maximum application rate is reduced to 0.03 lb ai/acre.

- Mixing, loading and applying liquids for ULV truck mounted spray application. The MOE at the maximum application rate of 0.08 lb ai/acre is 260 if an open cab is assumed. MOEs greater than the target MOE of 1000 result at the maximum application rate if a closed cab is assumed.

All other occupational exposure scenarios assessed based on master label specified uses result in MOEs greater than the applicable target MOEs.

6.0 Residential Exposure and Risk

Based on the master label, 12 residential exposure scenarios have been assessed for this RED. Only inhalation and incidental ingestion exposure assessments have been conducted for the residential scenarios. Dermal exposures were not assessed because no dose or endpoints were selected for dermal exposure. Acute, and short- and intermediate-term exposures are expected/assessed for residential exposure scenarios based on use and exposure patterns. Acute exposures are assessed for post-application inhalation exposure to aerial and curbside mosquito abatement applications and for exposures during and after application of aerosol space sprays indoors. Short and intermediate term exposures are assessed for all other handler and post-application exposure scenarios.

6.1 Residential Exposure Scenarios

The residential exposure assessment includes three handler and nine post-application residential exposure scenarios. The term "handler" applies to individuals who mix, load, and apply the pesticide product. The term "post-application" describes individuals who are exposed to pesticides after entering areas previously treated with pesticides. Based on information provided in the Piperonyl Butoxide Master Label regarding current registrant supported uses, HED assessed the following residential exposure scenarios for the piperonyl butoxide RED. Application of dust with shaker can, bulb duster, and power duster, a relevant and potentially significant exposure scenario, was not assessed due to lack of dust-specific or adequate surrogate data on inhalation exposure associated with this activity.

6.1.1 Handler Exposure Scenarios

1) Mixing, loading, and applying liquid spray formulation by low-pressure handwand for indoor surface spray application
2) Mixing, loading, and applying liquid spray formulation by low-pressure handwand for indoor crack and crevice treatment
3) Mixing, loading, and applying liquid spray formulation by hose-end sprayer for lawn and garden application.

6.1.2 Postapplication Exposure Scenarios

1) Inhalation exposure from application of mosquito adulticide from fixed wing aircraft and/or helicopter
2) Inhalation exposure from application of mosquito adulticide from ULV truck mounted sprayer
3) Toddler incidental ingestion of residue from treated turf grass via hand-to-mouth activities
4) Toddler incidental ingestion of residue via object-to-mouth activity while on treated turf grass
5) Toddler incidental ingestion of soil from treated area

6) Toddler incidental ingestion of residues deposited on carpet via hand-to-mouth activities after use of total release foggers
7) Toddler incidental ingestion of residues deposited on vinyl flooring via hand-to-mouth activities after use of total release foggers
8) Toddler incidental ingestion of residues on pets via hand-to-mouth activities after pet treatment
9) Inhalation exposure to aerosol spray during and after space spray application

6.2 Residential Exposure Data and Assumptions

6.2.1 Exposure Data

6.2.1.1 Application Parameters

Application rates for all of the exposure scenarios assessed are based on information provided in the Piperonyl Butoxide Master Label. The Piperonyl Butoxide Master Label lists all of the uses that the Piperonyl Butoxide Task Force II members are supporting. Therefore, it is important all labels be revised to reflect the supported uses and maximum allowable application rates provided in the Master Label.

6.2.1.2 Handler Exposure Data

Data from the PHED or ORETF data bases were used to assess residential handler exposures. Default application assumptions regarding areas treated or amounts applied for residential handler scenarios are documented in the HED Science Advisory Committee on Exposure SOP 12: "Recommended Revisions To The Standard Operating Procedures For Residential Exposure Assessment" (2/22/2001).

6.2.1.3 Post-application Exposure Data

HED Residential Exposure SOPs

The default factors used for the assessment are taken from the Exposure Science Advisory Committee SOP 12. SOP 12 provides values to assess post application inhalation and non-dietary ingestion exposure to lawn care pesticides, and indoor broadcast and crack and crevice treatments.

Non-Dietary Exposure Task Force Exposure Data

Primary assumptions for assessing post-application exposure to use of foggers and aerosols in indoor residential settings were based on data provided by the Non-Dietary Exposure Task Force (NDETF). The NDETF was formed in 1996 by members of the Pyrethrin Joint Venture (PJV) and Piperonyl Butoxide Task Force II (PBOTFII), Task Forces set up in the 1980s by producers, formulators, and marketers of the AIs to respond to reregistration needs. NDETF

includes; Bayer CropSciences, Botantical Resources Australia, Endura S.p.A, McLaughlin Gormley King Company, Pyrethrum Board of Kenya Prentiss Inc., S.C. Johnson and Son, Inc., Takasago International Corporation and Valent BioSciences Corporation. NDETF's purpose is to produce scientifically sound data on non-dietary exposures to pyrethrin, the pyrethroids, piperonyl butoxide, and MGK-264.

The NDETF conducted studies to examine the deposition of residues from total release foggers. The studies conducted with formulations of pyrethrin/piperonyl butoxide and permethrin/piperonyl butoxide were submitted to EPA in January 2004. The studies simulated the use of a fogger and aerosol products indoors to provide data on air dispersion and deposition on surfaces (walls, floor). Carpet and vinyl were selected as the flooring surfaces of interest because of their different physical and chemical properties and because they represent a significant amount of the floor coverings used in homes in North America. While the focus of the NDETF efforts was on total release foggers, a study was also conducted to determine both dispersion (air levels) and deposition (on flooring) of pyrethrin/piperonyl butoxide resulting from the use of a hand held aerosol spray can. Potential direct exposure of the user was also measured. Air sampling from the breathing zone of the applicator and analysis of residues on cotton gloves was performed. A more detailed evaluation of the NDETF Study data used for the piperonyl butoxide residential exposure assessment is provided in a separate review (D302120, B. Daiss, 5/11/04).

Spray Drift Task Force Exposure Data

HED used the AgDRIFT model to calculate airborne concentrations from aerial ULV applications. The model was developed by the Spray Drift Task Force, a coalition of pesticide registrants whose primary objective was to develop a comprehensive data base of off-target spray drift information along with an appropriate modeling system. The model has been peer reviewed by EPA's Science Advisory Panel and has been used in previous mosquito adulticide exposure assessments (e.g. carbaryl, malathion). AgDRIFT predicts the motion of spray material released from an aircraft, including the mean position of the material and the variance about the mean resulting from turbulent fluctuations. The model provides information on what percentage of the application volume remains aloft and what percentage of the resulting droplets is deposited on surfaces in the treated area and downwind. AgDRIFT allows for estimation of air concentration in breathing zones and residues deposited on turf. For this assessment, however, only breathing zone concentrations were estimated using AgDRIFT because dermal exposure is not a route of concern for piperonyl butoxide, and estimates of turf deposition used for assessing incidental ingestion were based more conservatively on direct application of piperonyl butoxide to turf grass. Turf grass application involves a higher application rate and a more direct application pathway.

6.2.2 Exposure Assumptions

The following assumptions were used in estimating risks from residential exposure to piperonyl butoxide:

- Average body weight of an adult is 70 kg
- Average body weight of a toddler is 15 kg
- Exposure is assessed on day of application (i.e., day zero)
- Exposure duration is short- and intermediate-term unless otherwise indicated (i.e., acute exposures for mosquito and indoor space spray scenarios)
- Maximum application rates as provided by the Piperonyl Butoxide Task Force II were used for all types and methods of application; rates used for exposure assessment are provided in Table 4
- Maximum daily volumes handled and/or area treated are as follows
  - 0.5 acre is used to represent the surface area treated for broadcast applications to lawns using garden hose-end sprayer;
  - average home treated with space spray or crack and crevice treatment has 1600 square feet of surface area
- Mosquito Abatement Scenario
  - for aerial application
    · fixed wing aircraft release height is 100 feet
    · rotary aircraft release height is 30 feet
    · average droplet size is 50 microns (per label and/or Public Health Pesticide Applicator Manual (25-50 microns))
    · wind speed is 2 mph (per label and/or Applicator Manual (<10 mph))
    · temperature is 86° F (per label and/or pesticide Applicator Manual (50-95° F))
  - for truck mounted ULV spray application a dilution factor of 0.01 is applied to the airborne concentration at the maximum application rate (i.e., 1% of product released is available for exposure)
  - breathing zone airborne concentration is estimated to be approximately 4-6 ft from the ground
  - adult breathing rate is 1.0 m^3 per hour; child breathing rate is 0.8 m^3 per hour (NAFTA breathing rates for light activity)
  - exposure duration is $\leq$ 2 hours
  - exposure is assessed as an acute exposure
- Toddler Outdoor (turf) and Indoor Fogger (carpet and vinyl) Hand to Mouth Scenario
  - estimated turf transferable residue is assumed to be 5% of the maximum application rate for sprays
  - indoor surface residue is 10 $\mu g/cm^2$ based on NDETF study data and a maximum application rate of 0.033 lbs ai/1000 ft^3 for indoor foggers
  - hand transfer efficiency is 13% for carpet; 8% for vinyl based on NDETF data
  - saliva extraction factor is 50 percent
  - surface portion of hand put in mouth is 20 cm^2
  - hand-to-mouth exposure frequency is 20 times per hour
  - saliva extraction factor is 50 percent
  - Exposure duration is 2 hours
- Toddler Object to Mouth Scenario
  - object to mouth transfer efficiency is equal to 20% of the application rate
  - ingestion rate of residues from mouthing turf or a small object is 25 cm^2

- Toddler Incidental Soil Ingestion Scenario
  - soil ingestion rate is 100 mg/day
  - fraction of ai available in uppermost cm of soil (fraction/cm) is 100 percent based on soil incorporation into top 1 cm of soil after application
- Toddler Pet Treatment Hand to Mouth Scenario
  - one half of a 16 oz spray container is used to treat each animal
  - transferable residue from a treated pet is assumed to be 20% of the maximum application rate for sprays
  - surface area of a treated (30 lb) dog is 6000 cm^2 (EPA 1993 Wildlife Exposure Factors Handbook - carbaryl)
  - saliva extraction factor is 50 percent
  - surface portion of hand put in mouth is 20 cm^2
  - frequency of hand-to-mouth events is one per day (frequency modified to reflect transferable residue assumption which is based on a 5 minute heavy rubbing/petting technique that would lead to significantly higher hand concentrations than would result from a single contact)
- Inhalation during and after aerosol space spray application
  - ·one 16 oz spray can containing likely maximum of 2.5% ai is used per application ·one application per home
  - adult breathing rate is 1.0 m^3 per hour; child breathing rate is 0.8 m^3 per hour
  - exposure duration is $\leq$2 hours

Non-Standard Exposure Assumptions

- Substance and scenario specific data from the NDETF study was used to determine deposition of piperonyl butoxide on vinyl and carpet flooring following use of a total release indoor fogger. NDETF data were also used to determine transfer of piperonyl butoxide residues from fogger treated vinyl and carpet flooring to the hands of a playing toddler. A more detailed evaluation of the NDETF Study data used for the piperonyl butoxide residential exposure assessment is provided in a separate review (D302120, B. Daiss, 5/11/04).

- Post-fogger release floor concentration was assumed to be 10 $\mu g/cm^2$. This is based on data from NDETF Study Volume 2, "Post-Application Deposition Measurements for Pyrethrins & Piperonyl Butoxide Following Use of a Total Release Indoor Fogger". The measured mean floor concentration was 5 $\mu g/cm^2$ following fogger application at the rate of 0.0015 lb ai per 1000 ft^3. The measured deposition was adjusted to reflect a maximum application rate of 0.03 lb ai per 1000 ft^3. HED used the mean measured deposition which excluded the concentration on the floor center coupon because the coupon under the total release canister appeared to be an outlying data point. The maximum piperonyl butoxide concentration measured on the coupon under the total release canister was 262 $\mu g/cm^2$. The next highest concentration was 15 $\mu g/cm^2$ on a coupon at a distance of two feet from the canister. This deposition pattern was not repeated in findings from NDETF Study Volume 23, "Post-Application Deposition Measurements for Permethrin and Piperonyl

Butoxide Following Use of a Total Release Indoor Fogger". The mean floor concentration including the floor center coupon was 13 μg/cm^2.

- Transfer of piperonyl butoxide from fogger treated carpet was assumed to be 13% of deposition based on data from Volume 29 of the NDETF Study, "Measurement of Transfer of Permethrin and Piperonyl Butoxide Residues from Vinyl and Carpet Flooring Treated with a Fogger Formulation to DSS Wetted Hands Following a Single Hand Press". Transfer of piperonyl butoxide from fogger treated vinyl flooring was assumed to be 8% of deposition based on data from Volume 13 of the NDETF Study, "Measurement of Transfer of Pyrethrin and Piperonyl Butoxide Residues from Vinyl and Carpet Flooring Treated with a Fogger Formulation to DSS Wetted Hands Following a Single Hand Press".

- Indoor air concentration for the period during and after aerosol space spray application was assumed to be 6 mg per cubic meter based on data from Volume 18 of the NDETF Study, "Measurement of Air Concentration , Dermal Exposure, and Deposition of Pyrethrin and Piperonyl Butoxide Following the Use of an Aerosol Spray". The measured time weighted average air concentration over a two hour period was 0.05 μg/L following aerosol application of small amount of a 1% ai formulation (1/20th of a can or 9.3 grams of a 170 gram container) to a simulated residential room measuring of 2048 ft^3. The measured air concentration was adjusted to reflect a likely maximum application rate of 0.025 lb ai per 16 oz can of aerosol spray in a similar size room. Inhalation following release of an aerosol fogger was not modeled separately because the aerosol spray application scenario is likely to provide a more conservative exposure estimate and therefore be protective of exposures following fogger release. The aerosol spray application involves more direct and immediate exposure and application rates for total release foggers, while higher, do not significantly exceed those of aerosol sprays. Labels for use of total release foggers require that the room be closed and vacated during release of the fogger and that the room be opened and air for a period of time (e.g. 30 minutes, 1 hour) prior to reentry.

- The approach for estimating air concentrations from truck-mounted ULV spray applications is based on the SOP for residential exposure assessment for inhalation exposure from use of an outdoor space spray for pest control. The approach was modified to assume that 1% of the highest application rate for a truck mounted ULV sprayer is available in the breathing zone of the resident. It is assumed that the full application rates for a truck-mounted ULV sprayer (with a one percent dilution factor) is available in the breathing zone of the residential bystander, i.e., an application rate expressed as lbs. ai/ft^2, is converted into a concentration expressed in a per cubic foot (ft^3) basis.

6.3 Residential Exposure and Risk Estimates

A target MOE of 100 is considered adequate for acute exposure via inhalation. A target MOE of 100 is considered adequate for short- and intermediate-term incidental ingestion

exposures. A target MOE of 300 is considered adequate for short- and intermediate-term inhalation exposures. Mosquito abatement post-application and indoor aerosol space spray application scenarios are assessed as acute exposures. All other residential handler and post-application exposure scenarios are assessed as short- and intermediate-term exposures. Exposure and risk estimates for each scenario are summarized below and a more detailed summary of risk calculations, critical assumptions, and results is provided in Tables 8-13 pages 27-30.

The results of the residential exposure assessment indicate that all residential exposure scenarios assessed based on master label specified uses result in MOEs greater than the applicable target MOEs. All residential scenarios result in exposures below the level of concern.

7.0 Uncertainties and Risk Characterization

Initial exposure estimates for this assessment are based on use of maximum application rates provided in the master label. It was also assumed, based on the master label, that products for all applications are supported/available in multiple forms i.e., liquids, dust, wettable powders. However, given that the majority of piperonyl butoxide products are available as liquid formulations, scenarios involving handling and application of liquid formulations are likely to be more representative of actual exposure.

The SOP default occupational and residential unit exposures selected for each scenario were based on central-tendency values from PHED. Summary descriptions of these data are provided in Table 14. The mean exposure data from the NDETF study used to estimate exposures from indoor fogger release is comprehensive and should accurately represent likely exposures from total release foggers.

Uncertainties identified by BEAD regarding the NPMA survey data used to determine potential exposures to PCO should also be noted. Regarding the robustness and validity of the NPMA survey data BEAD drew the following conclusions. Given that there are approximately 19,000 PCO firms in the U.S., it is highly unlikely that a sample size of 67 represents a statistically valid sample. The use of a retrospective survey methodology may have introduced errors in the data. Pesticide survey firms like Doane use a prospective survey instrument sent to growers in advance thus allowing them to keep detailed accounts of their pesticide usage in real time throughout the year. Despite its small size and retrospective methodology, however, the information collected is more robust than BEAD typically gets when asking questions of this nature. BEAD typically contacts 1-5 PCO's and asks chemical specific questions which may bias the responses if PCO's value the chemical under review. HED believes the NPMA survey provides reasonable estimates of average number of buildings treated per day by PCOs.

For pest control operator and mosquito abatement scenarios, assuming full day, long-term application for each application method may significantly overestimate total exposure. Based on data on usage of likely piperonyl butoxide containing pesticides presented in the NPMA survey, this assumption would result in significant overestimate of exposure for PCOs. Similarly, assuming continuous usage of piperonyl butoxide containing pesticides for mosquito abatement applications would also significantly overestimate total exposure based on personal

communication with mosquito control district officials regarding current usage of these products. However, piperonyl butoxide is used to control a large number and a wide variety of pests and labels do not restrict or preclude repeated applications or long term use. Given the potential for multiple applications and long-term use for occupational handlers, inclusion of a repeated use/long-term exposure scenario for pest control operators and mosquito abatement is considered reasonable.

Application of dust with shaker can, bulb duster and power duster, a relevant and potentially significant exposure scenario for both residential and occupational exposures, was not assessed due to lack of dust-specific or adequate surrogate data on inhalation exposure associated with this activity. Use of existing applicator data for surrogate exposure assumptions would likely underestimate potential risk

Tables 4-7 – Occupational Exposure and Risk Estimates

Table 4. Piperonyl Butoxide Inhalation Exposure & MOEs for Agricultural Handler Activities Target Short and Intermediate Term MOE = 300						
Exposure Scenario	**Inhalation Unit Exposure (µg/lb ai)[1]**	**Crop[2]**	**Application Rate[3]**	**Daily Area Treated[4]**	**Inhalation Dose (mg/kg/day)[5]**	**Inhalation MOE[6]**
Mixer/Loader						
Mixing/Loading Liquids for Aerial and/or Chemigation application (1)	1.2	Field Crops	0.50 lb ai/acre	350 Acres/day	0.003	1300
		High Acre Crops		1200 A/day	0.01	380
Mixing/Loading Liquids for Groundboom application (2)	1.2	Field Crops	0.5 lb ai/acre	80 Acres/day	0.00069	5800
Mixing/Loading Liquids for Airblast application (3)	1.2	Field Crops	0.5 lb ai per acre	40 Acres/day	0.00021	19000
Mixing/Loading Wettable Powders for Aerial application and/or Chemigation application (4)	43	Field Crops	**0.50** lb ai/acre	350 Acres/day	0.11	**40**
			0.06 lb ai/acre		0.013	310
		High Acre Crops	**0.50** lb ai/acre	1200 Acres/day	0.37	**11**
			0.018 lb ai/acre		0.013	300
Mixing/Loading Wettable Powders for Groundboom application (5)	43	Field Crops	**0.50** lb ai/acre	80 Acres/day	0.025	**160**
			0.25 lb ai/acre		0.012	325
Mixing/Loading Wettable Powders for Airblast application (6)	43	Field Crops	0.50 lb ai/acre	40 Acres/day	0.012	330
Applicator						
Sprays for Aerial application (7)	0.07	Field Crops	0.50 lb ai/acre	350 Acres/day	0.00018	23000
Sprays for Groundboom applic (8)	0.74	Field Crops	0.50 lb ai/acre	80 Acres/day	0.00042	9500
Sprays for Airblast application (9)	4.5	Field Crops	0.50 lb ai/acre	40 Acres/day	0.0013	3100
Mixer/Loader/Applicator						
Mixing/Loading/Applying Liquids for High-Pressure Handwand application (10)	120	Greenhouse	**1.5** lb ai/acre	10 Acres/day	0.026	**160**
			0.07 lb ai/acre		0.012	330
Mixing/Loading/Applying Liquids for Low Pressure Handwand or Backpack Sprayer application (11)	30	Greenhouse	1.5 lb ai/acre	2 Acres/day	0.0013	3100
Mixing/Loading/Applying Wettable Powders for Low-Pressure Handwand or Backpack Sprayer application (12)	1100	Greenhouse	**1.5** lb ai/acre	2 Acres/day	0.05	**85**
			0.4 lb ai/acre		0.013	320
Mixing/Loading/Applying Liquids for Low Pressure Handwand or Backpack Sprayer application (13)	30	Outdoor Premise & Equipment	1 lb ai/acre	2 Acres/day	0.0009	4700
Flagger						
Flagging for Spray application (14)	0.35	Field Crops	0.5 lb ai per acre	350 Acres per day	0.00088	4600

[1]Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.
[2]Crops and use patterns are from the master label
[3]Application rates are based on maximum values provided in the master label Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).
[4]Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).
[5]Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/ g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).
[6]Inhalation MOE = short-term and intermediate-term endpoint for inhalation; 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose. Target Short and Intermediate Term Inhalation MOE is 300. Target Long Term Inhalation MOE is 1000.

Table 5. Piperonyl Butoxide Inhalation Exposure & MOEs for Pesticide Control Operator Activities Target Short and Intermediate Term MOE = 300 Target Long Term MOE = 1000

Exposure Scenario	Inhalation Unit Exposure (µg/lb ai)[1]	Use[2]	Application Rate[3]	Daily Area Treated[4]	Inhalation Dose (mg/kg/day)[5]	Inhalation MOE[6]
Mixer/Loader/Applicator						
Mixing/Loading/Applying Liquids for Low Pressure Handwand application -Surface Spray (1)	30	Indoor Surface Spray	0.56 lb ai per 1000 sf	7 buildings avg area treated - 1600 sf	0.0034	1500
Mixing/Loading/Applying Liquids for Low Pressure Handwand application - Crack & Crevice Treatment (2)	30	Indoor Crack & Crevice	2.2 lb ai per 1000 sf	**7** buildings avg area treated - 1600 sf	0.12	**380**
				1 building avg area treated - 1600 sf	0.0004	2700
Mixing/Loading/Applying Wet Powders for Low Pressure Handwand application - Surface Spray (3)	1100	Indoor Surface Spray	**0.56** lb ai per 1000 sf	**7** buildings avg area treated -1600 sf	0.113	**40**
				1 building avg area treated - 1600 sf	0.0015	**280**
			0.16 lb ai per 1000 sf	**1** building avg area treated - 1600 sf	0.004	1020
Mixing/Loading/Applying Wettable Powders for Low Pressure Handwand application - Crack & Crevice Treatment (4)	1100	Indoor Crack & Crevice	**2.2** lb ai per 1000 ft^2	**7** buildings avg area treated - 1600 sf	0.385	**10**
				1 building avg area treated - 1600 sf	0.055	**70**
			0.16 lb ai per 1000 ft^2	**1** building avg area treated - 1600 sf	0.004	1020
Mixing/Loading/Applying Liquids for Low Pressure Handwand and Backpack Sprayer application (5)	30	Outdoor Premise	3.5 lb ai per acre	2 acres per day	0.003	1300
Mixing/Loading/Applying Liquids for Handgun (lawn) Sprayer application (6)	1.8	Lawn Care	1 lb ai per acre	5 Acres per day	0.00013	31000
Mixing/Loading Liquids for Groundboom application (7)	1.2	Golf course	1 lb ai per acre	40 Acres per day	0.0007	5800

Table 5. Piperonyl Butoxide Inhalation Exposure & MOEs for Pesticide Control Operator Activities
Target Short and Intermediate Term MOE = 300 Target Long Term MOE = 1000

Exposure Scenario	Inhalation Unit Exposure (µg/lb ai)[1]	Use[2]	Application Rate[3]	Daily Area Treated[4]	Inhalation Dose (mg/kg/day)[5]	Inhalation MOE[6]
Mixing/Loading/Applying Liquids for Low Pressure Handwand and Backpack Sprayer application (8)	30	Stored Grain	0.5 lb ai per 1000 ft^2	5 bins per day 1000 ft2 per bin	0.0011	3700
Mixing/Loading/Applying Liquids for High-Pressure Handwand application (9)	120	Stored Grain	0.5 lb ai per 1000 ft^2	5 bins per day 1000 ft2 per bin	0.0043	930
Mixing/Loading/Applying Liquids for Low-Pressure Handwand application (10)	30	Stored Produce	0.1 lb ai per 1000 ft^2	5 storage facilities per day 10000 ft2 per facility	0.0021	1900
Applicator						
Sprays for Groundboom application (11)	0.74	Golf course	1 lb ai per acre	40 Acres per day	0.0004	9500
Sprays for Aerosol Application (12)	1300	Indoor Space Spray	**0.025** lb ai per 16 oz can	7 homes per day 2 cans per home	0.0065	**615**
			0.012 lb ai per 16 oz can		0.0033	1200

[1]Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.
[2] Use patterns are from the master label
[3]Application rates are based on maximum values provided in the master label Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).
[4]Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).
[5]Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/ g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).
[6]Inhalation MOE = short-term and intermediate-term endpoint for inhalation; 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose. Target Short and Intermediate Term Inhalation MOE is 300. Target Long Term Inhalation MOE is 1000.

Table 6. Piperonyl Butoxide Inhalation Exposure & MOEs for Mosquito Abatement Activities
Target Short and Intermediate Term MOE = 300 Target Long Term MOE = 1000

Exposure Scenario	Inhalation Unit Exposure (µg/lb ai)[1]	Use[2]	Application Rate[3]	Daily Area Treated[4]	Inhalation Dose (mg/kg/day)[5]	Inhalation MOE[6]
Mixer/Loader						
Mixing/Loading Liquids for Aerial application (1)	1.2	Mosquito Control	**0.08** lb ai per acre	7500 Acres per day	0.0100	**390**
			0.03 lb ai per acre		0.0040	1000
Mixing/Loading Liquids for ULV truck mounted spray application (2)	1.2	Mosquito Control	0.08 lb ai per acre	3000 Acres per day	0.0041	970
Mixer/Loader/Applicator						
Sprays for ULV truck mounted spray (Airblast Surrogate Unit Exposure) (3)	4.5 **(Open Cab)**	Mosquito control	0.08 lb ai per acre	3000 Acres per day	0.0150	**260**
	0.45 **(Closed Cab)**				0.0004	2600
Mixing/Loading/Applying Liquids for Backpack sprayer application (4)	30	Mosquito Control	0.08 lb ai per acre	2 acres per day	0.00007	58000

[1]Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated

August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.
[2]Use patterns are from the master label
[3]Application rates are based on maximum values provided in the master label. Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by the label (i.e., presented as lb ai/gallon).
[4]Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).
[5]Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/ g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).
[6]Inhalation MOE = short-term and intermediate-term endpoint for inhalation; 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose. Target Short and Intermediate Term Inhalation MOE is 300. Target Long Term Inhalation MOE is 1000.

Table 7. Piperonyl Butoxide Inhalation Exposure & MOEs for Pet Groomer and Veterinarian Activities Target Short and Intermediate Term MOE = 300 Long-Term MOE =1000

Exposure Scenario	Inhalation Unit Exposure (µg/lb ai)[1]	Use[2]	Application Rate[3]	Daily Area Treated[4]	Inhalation Dose (mg/kg/day)[5]	Inhalation MOE[6]
Aerosol Application	1300	Pet Spray	0.03 lb ai per 16 oz can	8 pets treated per day ½ can of spray per pet	0.002	1800

[1]Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.
[2] Use pattern is from the master label
[3]Application rates are based on maximum values provided in the master label
[4]Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).
[5]Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/ g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).
[6]Inhalation MOE = short-term and intermediate-term endpoint for inhalation; 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose. Target Short and Intermediate Term Inhalation MOE is 300. Target Long Term Inhalation MOE is 1000.

Tables 8-13 - Residential Exposure and Risk Estimates

Table 8. Piperonyl Butoxide Inhalation Exposure & MOEs for Residential Handler Activities Target Short and Intermediate Term MOE = 300

Exposure Scenario	Inhalation Unit Exposure (µg/lb ai)[1]	Crop[2]	Application Rate[3]	Daily Area Treated[4]	Inhalation Dose (mg/kg/day)[5]	Inhalation MOE[6]
Mixing/Loading/Applying Liquids for Low Pressure Handwand application (1)	30	Indoor Residential Surface Spray	0.56 lb ai per 1000 ft^2	1 home of avg area of 1600 sf	0.0004	10400
Mixing/Loading/Applying Liquids for Low Pressure Handwand application (2)	30	Indoor Residential Crack & Crevice	2.2 lb ai per 1000 ft^2	1 home of avg area of 1600 sf	0.0015	2700
Mixing/Loading/Applying Liquids for Garden hose-end sprayer application (3)	11	Lawn	1 lb ai per acre	0.5 Acres per day	0.000079	51000

[1]Baseline inhalation unit exposures represent no respirator. Values are reported in the PHED Surrogate Exposure Guide dated August 1998 or are from data submitted by the Outdoor Residential Exposure Task Force dated May 2000.
[2]Crops and use patterns are from the master label
[3]Application rates are based on maximum values provided in the master label Most application rates upon which the analysis is based are presented as lb ai/A. In some cases, the application rate is based on applying a solution at concentrations specified by

the label (i.e., presented as lb ai/gallon).
[4]Amount treated is based on the area or gallons that can be reasonably applied in a single day for each exposure scenario of concern based on the application method and formulation/packaging type. (Standard EPA/OPP/HED values).
[5]Inhalation dose (mg/kg/day) = [unit exposure (ug/lb ai) * 0.001 mg/ g unit conversion * Inhalation absorption (100%) * Application rate (lb ai/acre or lb ai/gallon) * Daily area treated (acres or gallons)] / Body weight (70 kg).
[6]Inhalation MOE = short-term and intermediate-term endpoint for inhalation; 4 mg/kg/day (inhalation LOAEL)/ Daily Inhalation Dose. Target Short and Intermediate Term Inhalation MOE is 300. Target Long Term Inhalation MOE is 1000.

Table 9. Piperonyl butoxide Post-application Inhalation Risks To Adults and Children Following Mosquito Adulticide Application - Acute Target MOE = 100

Exposed Individual	Breathing Zone Concentration (mg/m^3)	Breathing Rate (m^3/hr)	Inhalation Dose ($mg/kg/day$)[1]	MOE
Aerial Spray (Fixed Wing and Rotary Aircraft) (1)				
Adult	0.03	1.0	0.0009	740000
Child	0.03	0.8	0.004	160000
Truck Mounted ULV Sprayer (2)				
Adult	0.3	1.0	0.005	75000
Child	0.3	0.8	0014	20000

ID (mg/kg/day) = Inhalation Dose = PDR/ BW
$PDR_{(t)}$ (mg/day) = $((AR_{t})$ (lb ai/A)-BZC * BR * ED
where:
PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m^3)
AR = application rate lb/ai per acre converted to mg/m^3
BZC = Breathing Zone Concentration (mg/m^3) - from Ag Drift Model for aerial spray application; 1% of application rate for truck mounted ULV sprayer application
BR = Breathing rate for adult or child (m^3/hr) (1.0 m^3/hr adult, 0.8 m^3/hr child)
BW = 70 kg for adult; 15 kg for toddler
ED = Exposure Duration (2 hr/day)
MOE = Acute Inhalation NOAEL (630 mg/kg/day)/Inhalation Dose (mg/kg/day) MOEs are reported to two significant figures.

Table 10. Piperonyl butoxide Post-application Incidental Ingestion Risks to Toddlers Reentering Treated Lawns Hand to Mouth (HTM), Object to Mouth (OTM), Incidental Soil Ingestion (SI), Aggregate - Short-Term Target MOE = 100

Inputs	Hand to Mouth (3)			Object to Mouth (4)			Soil Ingestion (5)			Aggregate
Max App Rate (lb ai/A)	Hand Transfer (ug/cm^2)	Daily Oral Dose (mg/kg/day)	MOE	Dislogeable Foliar Residue (ug/cm^2)	Daily Oral Dose (m/k/d)	MOE[3]	Soil Residue (ug/g)	Daily Oral Dose (m/k/d)	MOE	Aggregate MOE
1.0	0.56	0.015	6000	2.2	0.004	24000	0.00075	0.00005	>1E+06	4800

1 DOD(mg/kg/day) = Daily Oral Dose (PDR/ BW)
BW = 15 kg for toddler

Hand To Mouth Calculation
$PDR_{(t)}$ (mg/day) = $(HTF_{(t)}$ (µg/cm^2) * SEF * SA * Freq * ED/1000 (µg/mg)
where:
PDR = Potential Dose Rate at time (t) attributable for activity in a previously treated area (mg/day)
$HTE_{(t)}$ = Hand Transfer Efficiency at time t = 5% of Application Rate (µg/cm^2)
SEF = Saliva Extraction Factor (50%)
SA = Surface Area of Two Fingers (20 cm^2)
Freq = Frequency of Hand to Mouth Events (20)
ED = Exposure Duration in hours (2 hr/day)
t = Postapplication Day on which exposure is being assessed (day 0)
MOE = Short Term Oral NOAEL (89 mg/kg/day)/Daily Oral Dose (mg/kg/day)

Object to Mouth Calculation
$PDR_{(t)}$ (mg/day) = $(DFR_{(t)}$ (µg/cm^2) * SA/1000 (µg/mg)
where:
PDR = Potential Dose Rate at time (t) attributable for activity in a previously treated area (mg/day)

$DFR_{(t)}$= Dislogeable Foliar Residue at time t = 20% of Application Rate (µg/cm^2)
SA = Surface Area of grass or toy mouthed by toddler (25 cm^2 day)
t = Postapplication day on which exposure is being assessed (day 0)
MOE = Short Term Oral NOAEL (25 mg/kg/day)/[Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures

Soil Ingestion Calculation

$PDR_{(t)}$ (mg/day) = (SR_t * IgR * CF1)

where:

PDR = Potential Dose Rate - nondietary ingestion rate from contact with treated surface (mg/day)
SR_t = Soil Residue on day "t" (µg/g)
IgR = Ingestion Rate of soil (mg/day); (100 mg/day)
CF1 = Weight unit conversion factor (1E-6 g/µg)

where:

SR_t = Application Rate (µg/cm^2) * 1/cm * 0.67 cm^3/g soil [1/cm is fraction of ai available in uppermost cm of soil]
t = Postapplication Day on which exposure is being assessed, assumed to be day zero
MOE = Short Term Oral NOAEL (25 mg/kg/day)/[Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures
AggMOE=1/(1/MOE HTM + 1/MOE OTM + 1/MOE SI)

Table 11. Piperonyl butoxide Post-application Incidental Ingestion Risks To Toddlers Playing on Vinyl Floor and Carpet after Treatment with Fogger Formulation - Short-Term Target MOE = 100

Indoor Surface	Indoor Surface Residue (ug/cm^2)	Hand Transfer Efficiency (%)	Daily Oral Dose (mg/kg/day)[1]	MOE
carpet (6)	10	13	0.021	4200
vinyl (7)	10	8	0.035	2600

1 DOD(mg/kg/day) = Daily Oral Dose = PDR/ BW
$PDR_{(t)}$ (mg/day) = ($ISR_{t)}$ (µg/cm^2) * TE * SEF * SA * Freq * ED/1000 (µg/mg)

where:

PDR = Potential Dose Rate on day of application (mg/day)
ISR = Indoor Surface Residue (µg/cm^2) at maximum AR of 0.033 lbs ai/1000 ft^2
HTE = Hand Transfer Efficiency - transfer of (13% for carpet; 8% for vinyl)
SEF = Saliva Extraction Factor (50%)
SA = Surface Area of Two Fingers (20 cm^2)
Freq = Frequency of Hand to Mouth Events (20)
ED = Exposure Duration in hours = 2 hr/day
t = Postapplication Day on which exposure is being assessed (day 0)
BW = 15 kg for toddler
MOE = Short Term Oral NOAEL (89 mg/kg/day)/Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures.

Table 12. Piperonyl butoxide Post-application Incidental Ingestion Risks To Toddlers Playing with Pets after Treatment with Spray Formulation - Short-Term Target MOE = 100

Application Method	AR (mg ai/cm^2)	Transferable Residue (%)	Daily Oral Dose (mg/kg/day)[1]	MOE
Aerosol Spray (8)	1.14	20	0.15	600

1 DOD(mg/kg/day) = Daily Oral Dose = PDR/ BW
$PDR_{(t)}$ (mg/day) = (($AR_{t)}$ (mg ai/animal) * F)/SA_{pet}) * SEF * SA_{hands} * Freq

where:

PDR = Potential Dose Rate - nondietary ingestion dose from contact with treated pets (mg/day)
AR = Application Rate or amount applied to animal in a single treatment (mg ai/animal) = ½ of 16 oz spray container with maximum of 3% ai per 6000 cm^2/animal
F_{AR} = Fraction of Application Rate available for dermal contact as transferable residue (20%)
SA_{pet} = Surface Area of a treated dog (6000 cm^2/animal)
t = Time After Application (0 days)
SEF = Saliva Extraction Factor (50%)
SA_{hands}= Surface Area of the hands (20 cm^2)
Freq = Hand-to-Mouth Events (1 event/day)
BW = 15 kg for toddler
MOE = Short Term Oral NOAEL (89 mg/kg/day)/Daily Oral Dose (mg/kg/day) MOEs are reported to two significant figures.

Table 13. Piperonyl butoxide Inhalation Risks To Adults and Children During and After Indoor Space Spray Application - Acute Target MOE = 100					
Application Method	Exposed Individual	Breathing Zone Concentration (mg/m^3)	Breathing Rate (m^3/hr)	Inhalation Dose $(mg/kg/day)^1$	MOE
Aerosol Spray (9)	Adult	5.8	1.0	0.09	3800
	Child	5.8	0.8	0.28	1000

Inhalation Dose (mg/kg/day) = PDR/ BW

$PDR_{(t)}$ (mg/day) = (($AR_{(t)}$ (lb ai/A)- BZC * BR * ED

where:

PDR = Potential Dose Rate - inhalation dose in breathing zone after spray application (mg/m^3)
AR = application rate - 1 16 oz can containing 2.5% ai applied to a 16 x 16 x 8 ft room
BZC = Breathing Zone Concentration (mg/m^3) - measured air concentration from NDETF study adjusted to reflect a likely maximum application rate
BR = Breathing rate for adult or child (m^3/hr) (1.0 m^3/hr adult, 0.8 m^3/hr child)
BW = 70 kg for adult; 15 kg for toddler
ED = Exposure Duration (2 hr/day)
MOE = Acute Inhalation NOAEL (630 mg/kg/day)/Inhalation Dose (mg/kg/day) MOEs are reported to two significant figures.

Table 14. Default Inhalation Unit Exposure Values

Table 14. PHED/ORETF Inhalation Unit Exposure Values Used In Piperonyl Butoxide Occupational and Residential Exposure Assessment			
Scenario	Unit Exposure (ug/lb ai handled)	Replicates	Grade/Confidence
Occupational			
Mixing Loading Liquids	1.2	85	AB/High Confidence
Mixing Loading Wettable Powders	43	44	ABC/Medium Confidence
Aerial Spray Application	0.7	13	Low Confidence
Groundboom Application	0.74	16	AB/High Confidence
Airblast Application - Open Cab	4.5	47	AB/High Confidence
Airblast Application - Closed Cab	0.45	9	Low Confidence
Mix/Load/Apply Liquids High Pressure Handwand	120	13	A/Low Confidence
Mix/Load/Apply Liquids Low Pressure Handwand	30	80	ABC/Medium Confidence
Mix/Load/Apply Liquids Backpack Sprayer	30	11	A/Low Confidence
Mix/Load/Apply WP Low Pressure Handwand	1100	16	ABC/Medium Confidence
Flagging - Liquid Formulations	0.35	28	AB/High Confidence
Mix/Load/Apply Liquids for Handgun (lawn)Spray	1.8	14	B/Low Confidence
Sprays For Aerosol Application	1300	15	AB/High Confidence
Residential			
Mix/Load/Apply Liquids - Garden Hose-end Spray	11	90	AB/High Confidence

Table 14. PHED/ORETF Inhalation Unit Exposure Values Used In Piperonyl Butoxide Occupational and Residential Exposure Assessment			
Scenario	Unit Exposure (ug/lb ai handled)	Replicates	Grade/Confidence
Occupational			
Mix/Load/Apply Liquids Low Pressure Handwand	30	80	ABC/Medium Confidence